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EXPERIMENTAL FORECASTS OF CONVECTIVE GUST POTENTIAL

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1. INTRODUCTION

Probability forecasts of convective gust potential (CGP) for 10 stations in the National Weather Service (NWS) Western Region will be available on teletypewriter during June through September of 1977. These predictions for the likelihood of surface wind gusts of 25 knots or greater associated with convective activity involve the use of both Model Output Statistics (MOS) and classical statistics. The CGP forecast equations were developed by the Techniques Development Laboratory (TDL) with support from the Western Region Scientific Services Division (SSD). The forecasts should be of particular interest to those NWS forecasters who are concerned with the hazards strong winds and thunderstorms pose to forestry, recreation, aviation, and many industrial activities.

The CGP teletype bulletin will be generated daily at approximately 1530 GMT. The forecasts cover an 8-hr period centered at 0000 GMT. Two forecasts are provided for each station; one is a complete probability estimate, while the other requires on-station input of observed upper-air and surface data.

2. METHOD

Figure 1 illustrates how we use the MOS approach (Glahn and Lowry, 1972) to develop the two types of CGP prediction equations--MOS PROB and MOS-RS-OBS. Forecast fields from the 1200 GMT cycle Limited-area Fine Mesh (LFM) model are interpolated to the sites of each of the test stations shown in Figure 1. These interpolated LFM forecasts are then screened by the use of a linear regression technique to develop the MOS PROB equations. In addition, we screen observed weather elements from 1200 GMT radiosondes and 1500 GMT surface reports in deriving the MOS-RS-OBS equations.

The CGP predictand is the occurrence (within $\pm$ 4 hr of 0000 GMT) of a surface wind gust of 25 knots or greater in conjunction with some indication of atmospheric instability in the vicinity of the station such as a thunderstorm, virga, or towering cumulus. These data are from May through September of 1973, 1974, and 1975, and May through August of 1976. Gusts associated with a frontal passage or a strong, well-organized pressure gradient are not used.

3. EQUATION CHARACTERISTICS

a. MOS PROB EQUATIONS

Our MOS PROB equations rely entirely on 1200 GMT cycle LFM forecasts and parameters computed from these LFM fields. Table 1 shows the various dynamic, thermodynamic, and moisture variables we screen as potential predictors. The K and total totals (TT) indices are computed as follows:

K = (850 mb Temp - 500 mb Temp) + 850 mb Dewpoint - (700 mb Temp - 700 mb Dewpoint)

TT = (850 mb Temp - 500 mb Temp) + (850 mb Dewpoint - 500 mb Temp)

The MOS PROB equation for Salt Lake City, Utah is shown in Table 2. Some predictors are binary; others are continuous. A binary predictor is given a value of one if the variable from which it is derived is less than or equal to a particular threshold value; otherwise the binary predictor is set to zero.

A combination of eight thermodynamic, dynamic, and moisture forecasts from the LFM model reduced the variance in the gust predictand at Salt Lake City by 21%. A total of 80 convective gusts occurred at this station during the period of our developmental data sample.

Table 3 is a summary of the reduction of variance, number of convective gusts, and number of LFM predictors in the equations for each of the 10 test stations. The MOS PROB equations contain seven or eight terms depending on whether the eighth term contributed an additional one half of one percent reduction of variance. Either the K or TT index is the first predictor in each equation. Billings, Montana experienced the greatest number of convective gusts (99), while Boise, Idaho had the fewest (40) during May through September of 1973-1975, and May through August 1976.

b. MOS-RS-OBS EQUATIONS

The MOS-RS-OBS equations contain observed weather elements from 1200 GMT radiosondes and/or 1500 GMT surface reports, in addition to forecasts from the LFM model. Table 1 shows the observed upper-air and surface predictors we screened. We calculated several stability indices from the radiosonde data. The upper level stability index (UI) is computed in the following manner:

UI = (400 mb Temp - Parcel Temp) + (300 Temp - Parcel Temp)

The two parcel temperatures are those obtained by lifting an atmospheric parcel from 500 mb to its LCL and then up the moist adiabat through 400 mb and 300 mb, respectively. In this development, we arbitrarily set the UI to a very stable value of +25 whenever the 500-mb LCL was above 400 mb. A paper by McDonald (1976) provides more information concerning the UI. It is a useful aid to forecasting strong gusts that are often produced by high level thunderstorms common in the Western U.S.

Since every station does not take an upper-air observation, we made the following test station-radiosonde assignments in consulation with the Western Region SSD:

Test Station	Assigned Radiosonde
Phoenix, Arizona	Tucson, Arizona
Tucson, Arizona	Tucson, Arizona
Las Vegas, Nevada	Yucca Flats, Nevada
Ely, Nevada	Ely, Nevada
Reno, Nevada	Winnemucca, Nevada
Salt Lake City, Utah	Salt Lake City, Utah
Pocatello, Idaho	Salt Lake City, Utah
Boise, Idaho	Boise, Idaho
Great Falls, Montana	Great Falls, Montana
Billings, Montana	Glasgow, Montana

In contrast, each test station uses the surface weather elements reported at its own site. We coded the observed total sky cover in the following manner:

Total Sky Cover	Code Number
Clear	0
Partial Obscuration	1
Thin Scattered	2
Thin Broken	3
Thin Overcast	4
Scattered	5
Broken	6
Overcast	7
Obscured	8

Table 4 shows the MOS-RS-OBS equation for Salt Lake City. Here, a combination of eight predictors from the three data sources reduced the variance in the developmental gust predictand by 24%. The data sample consisted of only 466 cases because of missing upper-air and surface reports. Convective gusts of 25 knots or more occurred on 78 occasions.

We required all the MOS-RS-OBS equations to use the observed UI as a predictor. We did this so that the potential for high level thunderstorms would be at least partially taken into account. All the MOS-RS-OBS equations contain eight terms. As indicated in Table 3, three to five of these are forecasts from the LFM model for any given station.

4. MESSAGES AND SCHEDULES

A sample CGP teletype bulletin is shown below. The MOS PROB forecasts are normal probability estimates ranging from 0% to 100%. However, due to the relatively infrequent occurrence of convective gusts in the developmental sample (i.e., generally less than 20% of the total cases), extremely high probabilities may seldom be forecast. The MOS-RS-OBS are partial forecasts, and will require on-station computation and input of all terms involving observed data. Only the contribution of the initial constant and the LFM forecasts is shown in the MOS-RS-OBS column of the teletype message. Gusts produced by frontal passages or strong, synoptic-scale pressure gradients will not be forecast by either set of equations.

FMUS44 KWBC 081200
EXPERIMENTAL CONVECTIVE GUST POTENTIAL (CGP) FCSTS
PERIOD--2000GMT 6/08/77 TO 0400GMT 6/09/77

	MOS PROB	MOS-RS-OBS
GTF	31	106
BIL	24	91
BOI	42	53
PIH	16	-11
SLC	45	-109
ELY	14	-15
RNO	29	17
LAS	53	247
PHX	27	142
TUS	31	94

The MOS PROB and MOS-RS-OBS equations have been sent to each of the 10 stations involved in this test. We encourage forecasters at these stations to complete the MOS-RS-OBS forecast and compare it with the MOS PROB estimate. The contribution of each observed term should be multiplied by 100% before it is added to the partial MOS-RS-OBS forecast. The total sky cover must be coded as shown in Section 3b, and the wind speed from the radiosonde needs to be converted from knots to m sec^{-1}. Upper-air U and V wind components may be obtained from the direction (DIR) in whole degrees and speed (S) in m sec^{-1} as follows:

$$U = -S \times \text{sine (DIR)}$$

$$V = -S \times \text{cosine (DIR)}$$

The constant level temperature obtained from the radiosonde report should be converted to °K (i.e., add 273 to the values in °C). Please refer to Table 1 for any questions concerning units.

Occasionally, the completed MOS-RS-OBS forecasts will exceed the usual probability limits of 0% and 100%. For these situations the final forecast can be truncated to the appropriate value of either 0% or 100%.

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REFERENCES

Glahn, H. R., and D. A. Lowry, 1972: The use of Model Output Statistics (MOS) in objective weather forecasting. J. Appl. Meteor., 11, 1203-1211.

MacDonald, A. E., 1976: Gusty surface winds and high level thunderstorms. Western Region Technical Attachment No. 76-14, NWS Western Region Scientific Services Division, Salt Lake City, Utah, 6 pp.

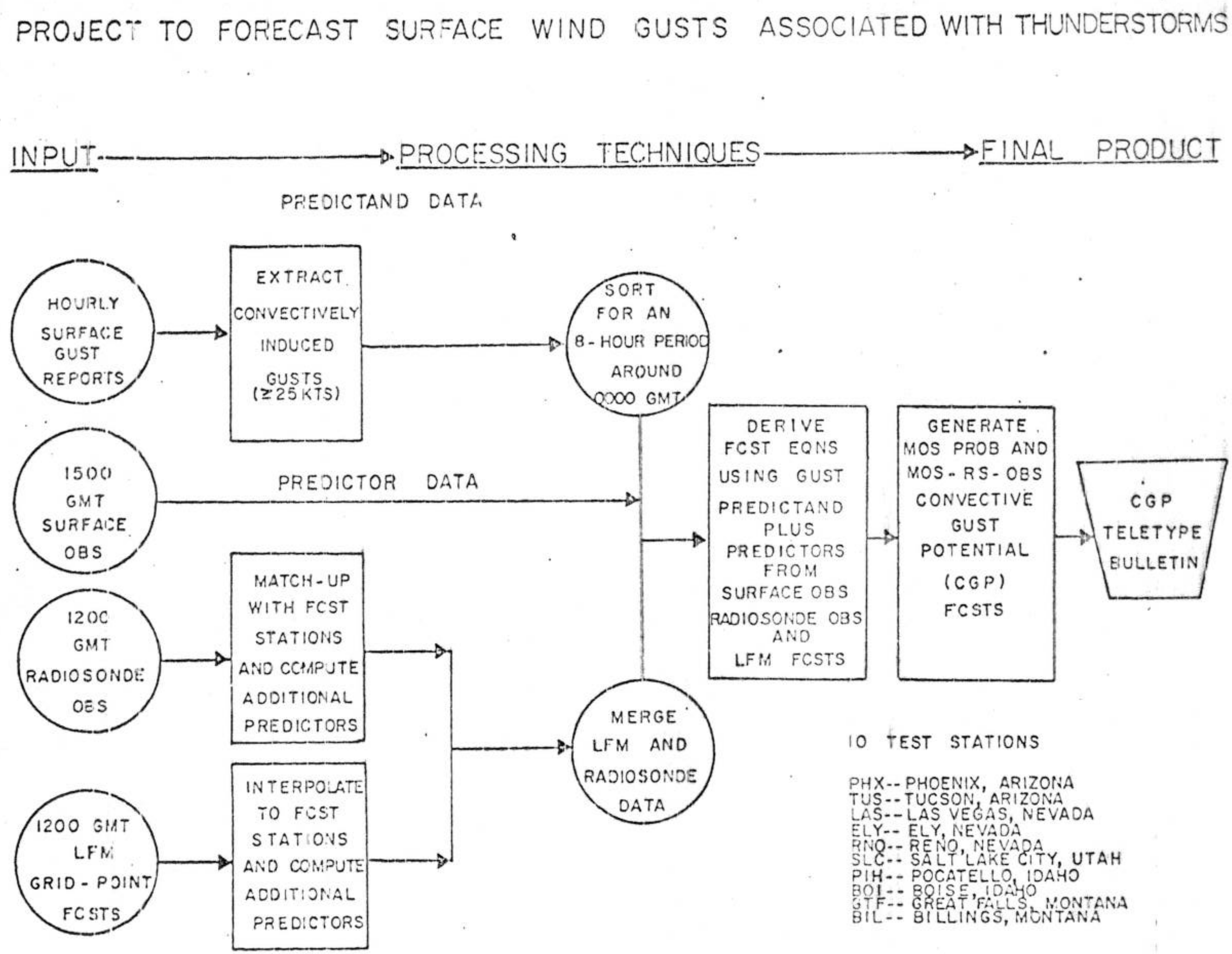

Figure 1. Data processing techniques and test stations used to develop the CGP prediction equations.

Table 1. Potential predictors available to the screening regression program for the development of CGP equations.

1200 GMT CYCLE 12-HR PROJECTION LFM FORECASTS		UNITS
Moisture ---------	Layer 1*, Layer 2*, and Mean Relative Humidity*	%
	850-, 700-, and 500-mb Dewpoint Depression	°C
Dynamics ---------	850-, 700-, and 500-mb Vertical Velocity	mb sec^{-1}
	850-, 700-, 500-, and 200-mb U Wind	m sec^{-1}
	850-, 700-, 500-, and 200-mb V Wind	m sec^{-1}
	850-, 700-, 500-, and 200-mb Wind Speed	m sec^{-1}
Thermodynamics --	500-850 and 500-700 mb Temperature Difference	°C
	850-, 700-, and 500-mb Temperature	°K
	850-, 700-, and 500-mb Dewpoint	°K
	K Index	°C
	Total Totals Index	°C
1200 GMT RADIOSONDE OBSERVATIONS		
Moisture --------	850-, 700-, and 500-mb Relative Humidity	%
Dynamics --------	850-, 700-, 500-, and 200-mb U Wind	m sec^{-1}
	850-, 700-, 500-, and 200-mb V Wind	m sec^{-1}
	850-, 700-, 500-, and 200-mb Wind Speed	m sec^{-1}
Thermodynamics --	500-850 and 500-700 mb Temperature Difference	°C
	850-, 700-, and 500-mb Temperature	°K
	Upper Level Stability Index	°C
	K Index	°C
	Total Totals Index	°C
1500 GMT SURFACE OBSERVATIONS		
	Temperature	°F
	Dewpoint	°F
	Total Sky Cover	Coded (0-8)

*The LFM forecast for the 6-hr projection is also screened for these three variables.

Table 2. The MOS PROB equation for Salt Lake City, Utah. Eighty convectively induced gusts occurred within ± 4 hr of 0000 GMT out of the 478 cases used to derive this equation. All predictors are forecasts from the LFM model.

Predictor	Forecast Projection (hr)	Binary Threshold	Cumulative Reduction of Variance (%)	Coefficient
Regression Constant	--	-----	--	-2.684
1. K Index	12	≤ 32°C	12	-0.135
2. 200-mb V Wind	12	≤ 0 m sec^{-1}	16	-0.125
Layer 2 Rel. Hum.	6	Continuous	17	0.002
4. 500-700 mb Temp. Diff.	12	Continuous	18	-0.056
5. 850-mb V Wind	12	≤-5 m sec^{-1}	19	0.258
6. 700-mb Wind Speed	12	Continuous	19	0.017
7. 500-850 mb Temp. Diff.	12	Continuous	20	0.025
8. 850-mb Dewpoint	12	Continuous	21	0.009

Table 3. Final reduction of variance (RV), ratio of the number of gusts (≥ 25 kt) to the total number of cases, and the number terms involving LFM forecasts for each of the experimental MOS PROB and MOS-RS-OBS equations.

Station	MOS PROB Equation			MOS-RS-OBS Equation		
	Final RV	Gusts/Total Cases	No. of Terms	Final RV	Gusts/Total Cases	No. of MOS Terms
Phoenix, Arizona	0.288	75/478	7	0.297	70/449	4
Tucson, Arizona	0.307	85/478	7	0.326	80/449	4
Las Vegas, Nevada	0.279	58/478	8	0.310	56/460	3
Ely, Nevada	0.365	94/478	7	0.355	86/453	4
Reno, Nevada	0.169	86/478	8	0.203	81/450	3
Salt Lake City, Utah	0.206	80/478	8	0.245	78/466	3
Pocatello, Idaho	0.207	83/478	8	0.205	83/467	5
Boise, Idaho	0.304	49/478	8	0.301	48/466	5
Great Falls, Montana	0.270	98/478	8	0.292	91/443	3
Billings, Montana	0.250	99/478	8	0.234	96/466	5
Overall Averages	0.264	81/478	8	0.277	77/457	4

Table 4. The MOS-RS-OBS equation for Salt Lake City, Utah. Seventy-eight convectively induced gusts occurred within ± 4 hr of 0000 GMT out of the 466 cases used to derive this equation.

Predictor	Fcst. Proj. or Obs. Time	Binary Threshold	Cumulative Reduction of Variance (%)	Coefficient
Regression Constant	----	----	----	0.062
1. Radiosonde Upper Level Stability Index	1200 GMT	≤ 9°C	8	0.174
2. LFM K Index	12 hr	≤ 32°C	16	-0.150
3. LFM 200-mb V Wind	12 hr	Continuous	18	0.003
4. Observed Sky Cover	1500 GMT	≤ Code 0 (clear)	20	-0.152
5. Observed Sky Cover	1500 GMT	≤ Code 6 (Broken)	22	0.168
6. Radiosonde 850-mb U Wind	1200 GMT	Continuous	23	-0.019
7. Radiosonde 500-mb Rel. Hum.	1200 GMT	Continuous	24	-0.001
8. LFM 850-mb Wind Speed	12 hr	Continuous	24	0.012